

423-10-01-7

EOS Polar Ground Station Project System Requirements

Volume 7

January 1998



National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

EOS Polar Ground Station Project System Requirements

Volume 7

September 1997

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Preface

This document provides the Level 2 requirements for the Earth Observing System (EOS) Polar Ground Station (EPGS).

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Abstract

This document provides a brief description of the EPGS and presents its Level 2 requirements, including programmatic, system, functional, performance, and interface requirements.

This document is a companion to the ESDIS Project Level 2 Requirements Volume 0: Overall ESDIS Project Requirements. Volume 0 should be consulted for understanding the Mission to Planet Earth (MTPE), the context of the EPGS, and the requirements hierarchy.

Keywords: *EPGS, EOS Polar Ground Station, ESDIS, Earth Science Data and Information System, EOSDIS, EOS Data and Information System, EOS, Earth Observing System, MTPE, Mission To Planet Earth.*

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Section 1. Introduction

1.1 Scope

This document establishes the Level 2 Earth Observing System (EOS) Data and Information System (EOSDIS) requirements for the EOS Polar Ground Station (EPGS) Project support of the Mission To Planet Earth (MTPE) missions. Missions supported by the EPGS include EOS spacecraft (AM-1, PM-1, LAM-1, CHEM-1), and other assigned MTPE spacecraft (Landsat-7 (L7), and EO-1). This document is a companion to the Earth Science Data and Information System (ESDIS) Project Level 2 Requirements Volume 0: Overall ESDIS Project Requirements, Reference 1. Reference 1 provides necessary information for understanding the Mission to Planet Earth, the context of the EPGS and the requirements hierarchy. Requirements affecting EPGS, such as those pertaining to the mission baseline and instrument complement, can be found in Reference 1 and will be referenced but not repeated here.

Only generic EPGS requirements are provided in this document. The requirements that are specific to the individual missions are specified in Appendix D of Reference 1. S-band telemetry data rates quoted in this document are rounded up to the nearest Kilobits per second (Kbps). Exact data rates are found in Reference 1.

1.2 Ground System Overview

The EOS is central to the MTPE, and is NASA's contribution to the Global Change Research Program. The EOS consists of three main components: the EOS Scientific Research Program, the EOSDIS and the EOS Space Measurement System (EOSSMS). The EOSDIS is a major component of the EOS Ground System (EGS). It is an integrated system of unique, dedicated, and shared subsystems and services that provide test, launch, and on-orbit operations for numerous Earth observing missions. The unique and dedicated portions of the EGS makeup most of its size, scope, and capability, complemented by shared or institutional subsystems. The EGS architecture can also be found in Reference 1.

Phase I of the EPGS, illustrated in Figure 1-1, provides operational support for L7 and contingency support for the AM-1 mission. Phase II of the EPGS, illustrated in Figure 1-2, provides operational support for both assigned MTPE missions starting with the PM-1 mission and the missions supported during Phase I.

The EPGS will inter-operate with other EOSDIS components and external interfaces such as EOS Data Operations System (EDOS), EOS Operations Center (EOC), EOS Backbone Network (EBnet), EOSDIS Test System (ETS), and Independent Verification and Validation (IV&V). Discussions of these systems can be found in the documents listed in Section 2.

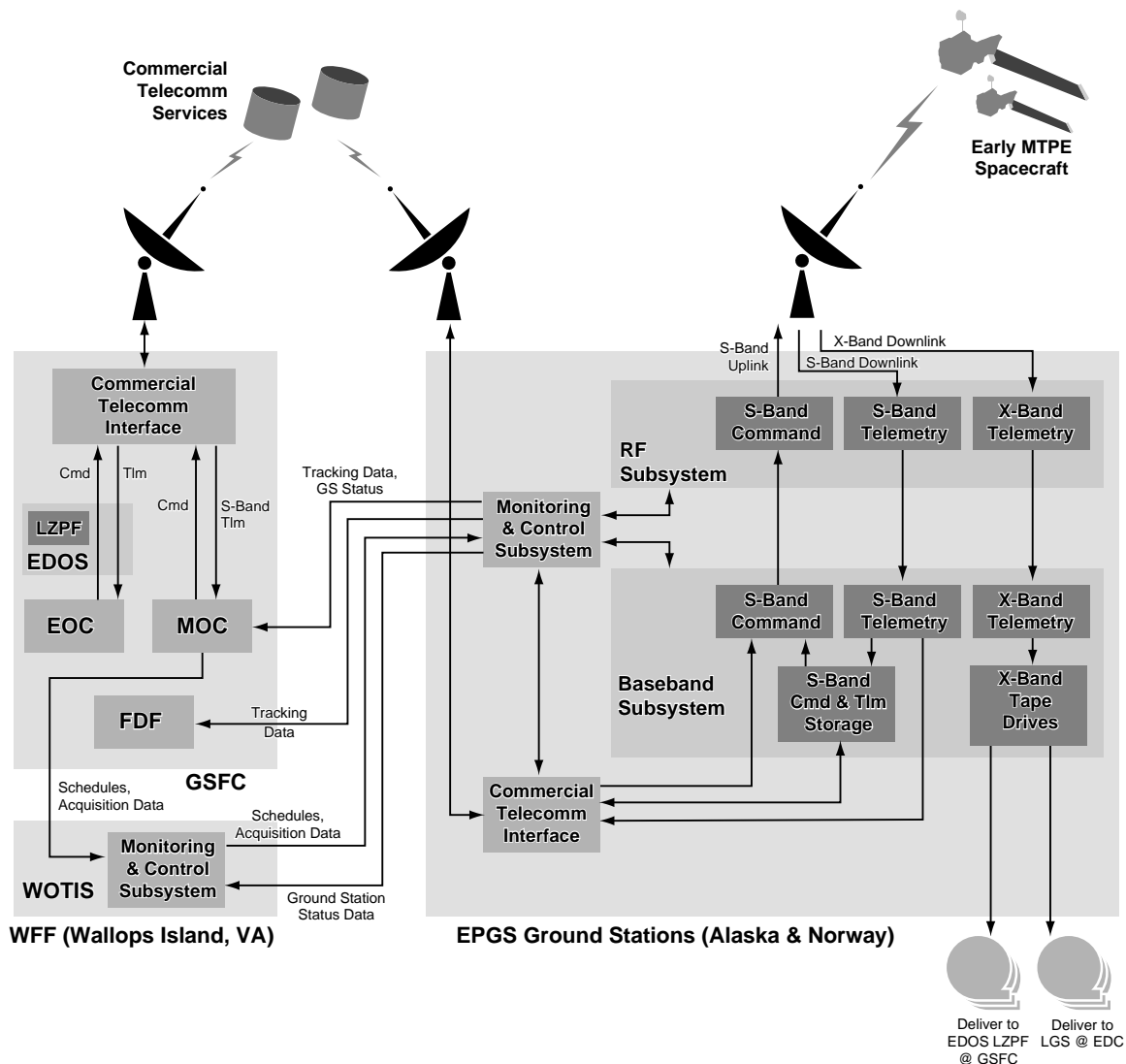


Figure 1-1. EPGS Phase I System Overview

1.3 EPGS Functional Objectives & Description

The EPGS support to assigned MTPE missions will include science data capture at S-band and X-band, as well as S-band Telemetry, Tracking and Command (TT&C) for spacecraft health and safety.

The EPGS consists of two stations: one located at Poker Flat Research Range, Fairbanks, Alaska, and one located at Longyearbyen, Spitsbergen, Svalbard, Norway. As shown in Figures 1-1 and 1-2, these stations consist of three primary subsystems: radio frequency (RF) subsystem, baseband data processing subsystem, and the monitor and control subsystem (MCS).

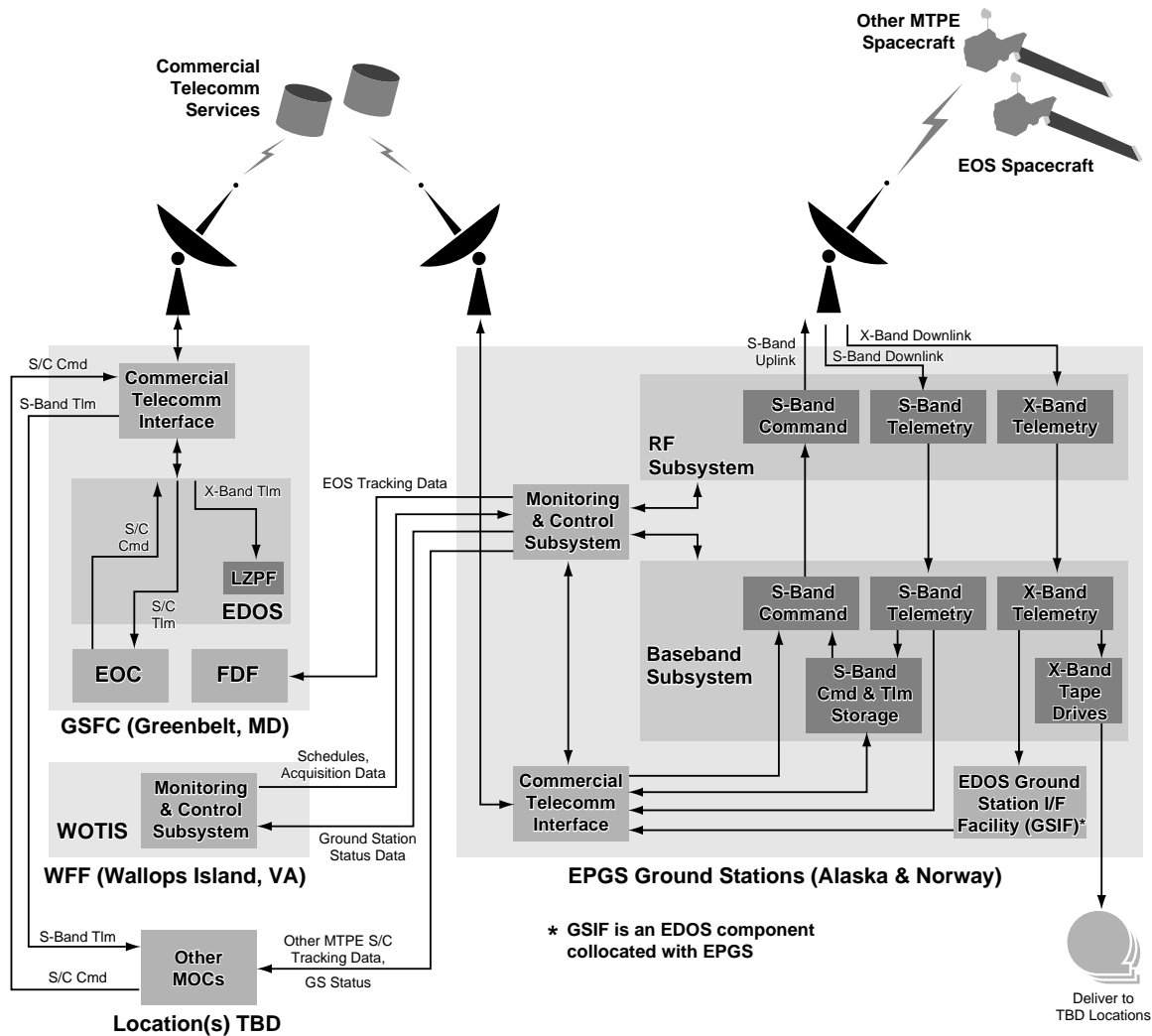


Figure 1-2. EPGS Phase II System Overview

The RF subsystem provides receive capability for X-band science data at rates up to 150 Megabits per second (Mbps), receive capability for S-band telemetry with two channels, one with a maximum data rate of 17 Kbps and the other with a maximum data rate of 525 Kbps, and command capability for S-band at 2 Kbps.

The baseband data processing subsystem (in conjunction with the EDOS Ground System Interface Facility (GSIF) in Phase II) captures and forwards science data to the EDOS Level Zero Processing Facility (LZPF) (or other mission data processing centers, electronically or via physical media), receives and forwards commands to the RF subsystem, and records data on magnetic tapes.

The MCS gathers parameters from RF and baseband processing equipment, and performs autonomous monitoring of key equipment health parameters during a pass. It also configures the station for pass support and conducts system performance tests based on the information

received from the Wallops Orbital Tracking Information System (WOTIS). The WOTIS functions as the EPGS control center. Assigned mission operations centers (MOCs) provide EPGS schedules to the EPGS stations via the WOTIS, and receive EPGS status data from the WOTIS.

Section 2. Reference Documents

The following documents are used in establishing the requirements in this document.

1. Earth Observing System Earth Sciences Data & Information System (ESDIS) Project Level 2 Requirements Volume 0: Overall EOS Ground System Requirements, 423-10-01-0, Revision A, December 1996.
2. ESDIS Project Level 2 Requirements Volume 1: EOSDIS Core System (ECS), 423-10-01-1, Revision B, December 1996
3. ESDIS Project Level 2 Requirements Volume 2: EOS Data and Operations System Requirements, 423-10-01-2, Revision A, December 1996.
4. ESDIS Project Level 2 Requirements Volume 3: Other ESDIS Project Requirements, 423-10-01-3, Revision A, December 1996
5. ESDIS Project Level 2 Requirements Volume 6: EOSDIS Backbone Network (EBnet), 505-10-01-6, Revision A, December 1996
6. Earth Observing System Polar Ground Station Project Management Plan, 530-PMP-EPGS, February 1997
7. EOSDIS Security Policy and Guidelines Document, 423-10-23, October 1997
8. Interface Control Document Between Landsat 7 and the Landsat 7 Ground Network (LGN), 430-14-01-001-0, August 1997
9. Reliability Program Provisions for Aeronautical and Space System Contractors, NHB5300.4 (1A-1), January 1987
10. Quality Program Provisions for Aeronautical and Space System Contractors, NHB5300.4 (1B), April 1969

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Section 3. EPGS Level 2 Requirements

3.1 Programmatic Requirements

	Requirement Statement	Requirement ID
3.1.1	The EPGS Project shall apply applicable international, national, commercial, agency, and Goddard Space Flight Center (GSFC) standards for development and operations.	270001
3.1.2	The EPGS Project shall maintain an up-to-date assessment of system use, product use, and user satisfaction.	270002
3.1.3	The EPGS Project shall provide for the control, configuration, problem reporting, maintenance and sustaining engineering of EPGS equipment at the Alaska and Norway facilities.	270003
3.1.4	The EPGS Project shall minimize development and sustaining engineering costs through judicious re-use of previously developed GSFC technology and the maximum application of commercial off-the-shelf (COTS) products.	270004
3.1.5	The EPGS Project implementation team shall coordinate with the ECS implementation team, the EDOS team, and EGS IV&V personnel, to assure the development of mutually compatible systems.	270005
3.1.6	The EPGS Project shall support the EGS IV&V in the verification and validation of the EPGS system functions.	270006
3.1.7	The EPGS Project shall provide a capability for trade-off studies, prototyping activities, and resolution of key technical issues throughout the life of the project.	270007
3.1.8	The EPGS Project shall provide the capability to support end-to-end system performance analyses.	270008
3.1.9	The EPGS Project shall establish a capability for remote management, monitoring, and control of the EPGS facilities in Alaska and Norway.	270009
3.1.10	The EPGS Project shall establish a capability for managing EPGS-supported MTPE spacecraft schedules and resolving conflicts.	270010
3.1.11	The EPGS Project shall predict and periodically assess maintainability by measuring the actual Mean-Time-to-Restore-Service (MTTRS) and comparing to the required MTTRS.	270011

3.2 System Level Requirements

	Requirement Statement	Requirement ID
3.2.1	The EPGS shall support science and housekeeping telemetry reception and commanding for assigned missions as defined in 423-10-01-0, Volume 0, Appendix D [Reference 1].	270012
3.2.2	The EPGS shall support science and housekeeping telemetry reception and commanding for other assigned MTPE missions including L7, and EO-1.	270013
3.2.3	The EPGS shall comply with the security policy and guidelines as specified in Reference 7.	270014
3.2.4	The EPGS shall conform to the reliability and quality assurance requirements stated in the NASA Handbook 5300.4, (1A-1) [Reference 9] Reliability and (1B) Quality Assurance [Reference 10], respectively.	270015
3.2.5	The EPGS shall receive, process and respond to schedules for EOS spacecraft support from the EOC.	270016
3.2.6	The EPGS shall receive schedules for other assigned MTPE spacecraft from their respective MOC, directly or indirectly via the WOTIS as appropriate.	270017
3.2.7	The EPGS shall be capable of providing services to EOS and other assigned MTPE spacecraft as defined in this document for 20 years.	270018
3.2.8	The EPGS shall maintain and assure the integrity of all data received, stored, and transmitted.	270019
3.2.9	The EPGS shall support assigned spacecraft pre-launch activities including compatibility tests, operational readiness tests, simulations, and end-to-end network tests.	270020
3.2.10	The EPGS shall provide EPGS system status information to the EOC and other assigned spacecraft MOCs, directly or indirectly via the WOTIS as appropriate.	270021
3.2.11	The EPGS shall have an automated test procedure to support pass readiness testing prior to each spacecraft contact.	270022
3.2.12	EPGS shall conform to all regulatory requirements pertaining to power flux density, out-of-band emissions, and interference with host sites.	270023
3.2.13	The EPGS shall provide the capability for remote ground station operations by incorporating automation and remote monitoring of equipment configurations.	270024

3.3 Functional Requirements

	Requirement Statement	Requirement ID
3.3.1	The EPGS shall receive spacecraft S-band and X-band RF signals and convert them to appropriate digital telemetry data.	270025
3.3.2	The EPGS shall receive EOS spacecraft commands in digital form from the EOC via the EDOS, and transfer the commands to the spacecraft.	270026
3.3.3	The EPGS shall receive commands in digital form from the MOCs of other assigned MTPE spacecraft, and transfer the commands to the spacecraft.	270027
3.3.4	The EPGS shall buffer uplink command data as necessary to ensure continuity of the modulated RF command signal.	270028
3.3.5	The EPGS shall be capable of monitoring all uplink and downlink S-band and X-band RF spectrums.	270029
3.3.6	The EPGS shall monitor and record the transmitted command data on non-volatile, physical media, and retain the recorded data until they are not needed.	270030
3.3.7	The EPGS shall be capable of providing simultaneous X-band telemetry, S-band telemetry, and S-band command support.	270031
3.3.8	The EPGS shall be capable of recording received X-band and S-band telemetry data on non-volatile, physical media, and retain the recorded data until they are not needed.	270032
3.3.9	The EPGS shall forward the received EOS X-band telemetry data to the EDOS GSIF.	270033
3.3.10	The EPGS shall forward the EOS S-band telemetry data to the EDOS LZPF.	270034
3.3.11	The EPGS shall forward S-band and X-band telemetry data from other assigned MTPE spacecraft to their respective MOC or sensor data processing facilities, as appropriate.	270035
3.3.12	The EPGS shall have the capability to perform both one- and two-way spacecraft Doppler tracking, to generate Universal Tracking Data Format (UTDF) tracking measurements, and to forward the tracking data measurements to the Flight Dynamics Facility (FDF) or to assigned spacecraft MOC, as appropriate.	270036
3.3.13	The EPGS shall have the capability to receive acquisition data from the FDF or from assigned spacecraft MOC.	270037
3.3.14	The EPGS shall support end-to-end fault isolation for all S-band and X-band services.	270038
3.3.15	The EPGS shall support end-to-end EGS testing.	270039

	Requirement Statement	Requirement ID
3.3.16	The EPGS shall store and execute automated configuration and reconfiguration sequences of EPGS equipment based on locally stored schedules of support requirements.	270040
3.3.17	The EPGS shall provide for local (on-site) control of equipment.	270041
3.3.18	The EPGS shall perform autonomous equipment status monitoring of all key equipment health parameters.	270042
3.3.19	The EPGS shall forward ground station operational status data to the EOC or to the assigned MTPE spacecraft MOC during a respective spacecraft pass.	270043
3.3.20	The EPGS shall provide summary status information, communications performance information, and accounting information for all mission support to the EOC and other MOCs as appropriate.	270044
3.3.21	The EPGS shall be capable of decoding convolutionally encoded S-band and X-band telemetry data streams.	270064
3.3.22	When requested, the EPGS shall replay the recorded S-band telemetry data to the requesting mission operations center (EOC or other assigned MOC).	270065
3.3.23	The EPGS shall make X-band telemetry data tapes available for delivery to appropriate destinations (e.g., EDOS during early AM-1 mission or LGS).	270066
3.3.24	The EPGS shall have the capability to support the spacecraft clock correlation.	270067
3.3.25	The EPGS shall have the capability to perform frame synchronization and Reed-Solomon decoding on S-band telemetry.	270068

3.4 Performance Requirements

	Requirement Statement	Requirement ID
3.4.1	The EPGS shall provide EOS mission support for the spacecraft downlink data rates defined in 423-10-01-0, Volume 0, Appendix D.	270045
3.4.2	The EPGS shall receive up to two simultaneous X-band telemetry data streams at rates up to 150 Mbps each.	270046
3.4.3	The EPGS shall receive up to two simultaneous S-band telemetry streams, each of which consists of two channels, one with a data rate up to 17 Kbps and the other with a data rate up to 525 Kbps.	270047
3.4.4	An RF signal, received at the EPGS antenna, shall be forwarded from the RF subsystem to the baseband data interface in real-time.	270048
3.4.5	The EPGS maximum S-band telemetry bit error rate (BER) shall be 10^{-5} with respect to the communication channel spanning the spacecraft transmitter and the ground terminal receiver output without Reed-Solomon decoding performed.	270049
3.4.6	The EPGS shall be capable of achieving maximum X-band telemetry BER of 10^{-5} with respect to the communication channel spanning the spacecraft transmitter and the ground terminal output (TBD).	270050
3.4.7	The EPGS shall receive commands from the baseband data interface and transmit the commands to the assigned spacecraft in real-time.	270051
3.4.8	The EPGS shall transmit S-band commands at 2 Kbps.	270052
3.4.9	The EPGS shall provide sufficient effective isotropic radiated power (EIRP) for command uplinking so that the spacecraft may attain BER of less than 10^{-5} with respect to the communication channel spanning the ground terminal transmitter and the spacecraft receiver output.	270053
3.4.10	The EPGS shall be capable of transmitting S-band signals selectively using Right Hand Circular (RHC) or Left Hand Circular (LHC) polarization.	270054
3.4.11	The EPGS shall be capable of receiving S-band and X-band signals selectively using RHC or LHC polarization.	270055
3.4.12	The EPGS maximum time-to-restore-service shall not exceed one minute.	270056
3.4.13	Each EPGS shall have a minimum service availability of 0.9998 measured over a contiguous 10,000 hour interval.	270057

3.5 Interface Requirements

	Requirement Statement	Requirement ID
3.5.1	The EPGS shall provide an RF interface to assigned spacecraft for the receipt of telemetry and for the transfer of command data.	270058
3.5.2	The EPGS shall provide an interface to the NASA Integrated Services Network (NISN) of sufficient capacity to accommodate a continuous data stream with data rates of up to 541 Kbps.	270059
3.5.3	The EPGS shall provide an interface to the EOC and other MTPE spacecraft MOCs for pre-pass checkout and pass monitor data.	270060
3.5.4	The EPGS shall provide an interface to the EDOS for EOS spacecraft S-band and X-band telemetry data, and S-band command data.	270061
3.5.5	The EPGS shall provide an interface to the MOCs of other assigned MTPE spacecraft for S-band and X-band telemetry data, and S-band command data.	270062
3.5.6	The EPGS shall provide an interface to the EDOS and MOCs of other assigned MTPE missions for schedule requests, schedule results, and monitor and control data.	270063

Abbreviations and Acronyms List

AM	EOS - Morning Crossing Mission
BER	Bit Error Rate
CHEM	EOS Chemistry Mission
CMD	Command
EBnet	EOS Backbone Network
ECS	EOSDIS Core System
EDC	EROS Data Center
EDOS	EOS Data Operations System
EGS	EOS Ground System
EIRP	Effective Isotropic Radiated Power
EOC	EOS Operations Center
EOS	Earth Observing System
EOSDIS	Earth Observing System Data and Information System
EOSSMS	EOS Space Measurement System
EPGS	EOS Polar Ground Stations
EROS	Earth Resources Observation Center
ESDIS	Earth Science Data and Information System
ETS	EOSDIS Test System
FDF	Flight Dynamics Facility
FOT	Flight Operations Team
GS	Ground Station
GSFC	Goddard Space Flight Center
GSIF	Ground System Interface Facility
IV&V	Independent Verification and Validation
Kbps	Kilobits per second
L7	Landsat 7
LAM	Laser Altimetry Mission
LGS	L7 Ground Station

LHC	Left Hand Circular
LZPF	Level Zero Processing Facility
Mbps	Megabits per second
MOC	Mission Operations Center
MTPE	Mission to Planet Earth
MTTRS	Mean Time To Restore Service
NISN	NASA Integrated Services Network
PB	Playback
PM	EOS - Afternoon Crossing Mission
RF	Radio Frequency
RHC	Right Hand Circular
RT	Real Time
S/C	Spacecraft
SN	Space Network
TBD	To Be Determined
TLM	Telemetry
TT&C	Telemetry, Tracking and Command
UTDF	Universal Tracking Data Format
WFF	Wallops Flight Facility
WOTIS	Wallops Orbital Tracking Information System